SPORT BALL WITH SELF-CONTAINED DUAL ACTION INFLATION MECHANISM

The present invention claims priority to U.S. Provisional Patent Application Serial No. 60/435,222 filed on December 20, 2002.

Field of the Invention

The present invention relates to sport or game balls that contain integral mechanisms for inflating or adding pressure to the balls. The inflation mechanisms are double action pumps instead of the single action pumps currently available in certain inflatable sport balls.

Background of the Invention

Conventional inflatable sport balls, such as basketballs, footballs, soccer balls, volleyballs and playground balls, are inflated through a traditional inflation valve using a separate inflation needle that is inserted into and through a self-sealing inflation valve on the ball. A separate pump, such as a traditional bicycle pump, is connected to the inflation needle and the ball is inflated using the pump. The inflation needle is then withdrawn from the inflation valve which then self-seals to maintain the air pressure within the ball. This system works fine until the ball needs inflation or a pressure increase and a needle and/or pump are not readily available.

More recently, inflatable sport balls have been developed that have integral pumps, but these pumps are only single action pumps. If a relatively large pressure increase is needed, it can be quite time consuming to add air and increase the ball's pressure. This is because the pumps are small and do not add a large volume of air with each stroke.

Summary of the Invention

An object of the present invention is to inflate or add pressure to a sport ball without the need for separate inflation equipment such as a separate inflation needle and pump, and to be able to add the air more quickly by reducing the number of strokes otherwise needed.

The present invention provides a sport ball having a self-contained dual action inflation mechanism. The invention also provides a ball having multiple self-contained inflation mechanisms, in which at least one of the inflation mechanisms is of the dual action type. As used herein, a "dual action" or "double action" pump or inflation mechanism refers to a pump that adds air on both the in (or down) stroke and the out (or up) stroke. Restated, the dual action pump introduces air to the ball in both directions of the pumping action.

More specifically, the invention relates to a sport ball that has at least one self-contained pump device which is operable from outside the ball and which pumps ambient air into the ball to achieve a desired pressure. Additionally, the pump is a double action or dual action pump. The dual action of the pump allows air to be introduced into the interior of the inflatable sport ball on both the forward stroke and the reverse stroke by drawing air into separate chambers on each stroke. The dual action pump will be described in more detail below. The pump mechanism may also have a pressure relief mechanism and/or a pressure indication device.

In a first aspect, the present invention provides a sport ball having an integral pump. The ball comprises a flexible ball body adapted to retain pressurized air. The body also defines an aperture. The ball additionally comprises a pump disposed in the aperture and retained within the ball body. The pump includes a cylinder, a piston disposed in the cylinder, and a valve assembly configured to introduce air into the ball body upon movement of the piston from an extended position to an inserted position. The valve assembly is also configured to introduce air into the ball body upon movement of the piston from the inserted position to the extended position.

In another aspect, the present invention provides an inflatable ball having an integral dual action pump assembly for changing air pressure within the ball. The ball comprises a rubber bladder defining an interior region adapted for retaining pressurized air. The ball also comprises an outer layer disposed about

the rubber bladder. And, the ball comprises a pump assembly disposed in the interior region of the rubber bladder. The pump assembly includes a movable plunger sealingly disposed within a cylinder secured to the rubber bladder. The plunger is movable in both a forward stroke and a reverse stroke. The pump assembly is adapted to transfer air to the interior region of the rubber bladder by moving the plunger in either of the forward stroke or the reverse stroke.

In yet another aspect, the present invention provides an inflatable sport ball having an integral dual-action pump assembly for changing air pressure within the ball. The ball comprises a ball carcass which defines an interior region for retaining air at a pressure greater than atmospheric pressure. The carcass defines an aperture between the interior region and the exterior of the ball. The ball also comprises a pump assembly disposed within the aperture and extending into the interior region. The pump assembly comprises a pump cylinder including an open end, a nozzle end, and a cylindrical sidewall extending between the open end and the nozzle end. The cylinder defines a generally hollow interior. The pump assembly also comprises a pump plunger having a cap end, a sealing end, and a tubular wall extending between the cap end and the sealing end. The plunger defines a generally hollow interior accessible from the sealing end. The plunger is movably disposed within the hollow interior of the cylinder between a forward position at which the sealing end of the plunger is proximate the nozzle end of the cylinder, and a reverse position at which the sealing end of the plunger is proximate the open end of the cylinder. Air is transferred into the interior region of the ball carcass upon movement of the plunger from the forward position to the reverse position or from the reverse position to the forward position.

In yet another aspect, the present invention provides a dual action pump adapted for incorporation in an inflatable sport ball. The pump comprises a cylinder having a head end, a nozzle end, and a cylindrical sidewall extending therebetween. The sidewall has an exterior surface and an oppositely directed interior surface. The cylinder defines a generally hollow interior chamber accessible from the head end and the nozzle end. The pump also comprises a movable plunger disposed in the hollow interior chamber of the cylinder. The plunger has a cap end, a sealing end, and a tubular wall extending therebetween. The plunger defines a hollow interior region accessible from the

sealing end. The pump also comprises an air transfer tube extending within both the hollow interior chamber of the cylinder and the hollow interior region of the plunger. The air transfer tube is secured to the nozzle end of the cylinder.

These and other objects and features of the invention will become apparent from the specification, drawings and claims.

Brief Description of the Drawings

The following is a brief description of the drawings, which is presented for the purposes of illustrating the invention and not for the purposes of limiting the same.

Figure 1 is a partial cross-sectional view of a basketball utilizing a preferred embodiment dual action pump in accordance with the present invention.

Figure 2 is a partial cross-sectional view of a football utilizing the preferred embodiment dual action pump in accordance with the present invention.

Figure 3 is a detailed cross-sectional view of a portion of the basketball depicted in Figure 1 illustrating a preferred mounting configuration for the dual action pump of the present invention.

Figure 4 is a detailed schematic view of a plunger component of the preferred embodiment dual action pump.

Figure 5 is a detailed schematic view of a pump cylinder component of the preferred embodiment dual action pump.

Figure 6 is a cross section of a preferred dual action pump according to the present invention illustrating air flow within a first chamber of the pump during a forward stroke.

Figure 7 is a cross section of the preferred dual action pump illustrating air flow within the first chamber during a reverse stroke.

Figure 8 is a cross section of the preferred dual action pump illustrating air flow within a second chamber during a forward stroke.

Figure 9 is a cross section of the preferred dual action pump illustrating air flow within the second chamber during a reverse stroke.

Figure 10 is a perspective view of a preferred cylinder cap used for securing the dual action pump within a game ball.

Figure 11 is a partial cross section of a game ball illustrating the mounting configuration between the dual action pump, the cylinder cap, and a boot.

Figure 12 is a cross section of a preferred nozzle component for use in the dual action pump of the present invention.

Figure 13 is a cross section of a preferred duckbill valve used in the nozzle component illustrated in Figure 12.

Figure 14 is another preferred embodiment of a game ball according to the present invention.

Description of the Preferred Embodiments

The present invention relates to a sport or game ball having an integral dual action pump. The pump is retained within the ball and may be easily used to introduce air into the ball and thereby inflate the ball.

The pump preferably comprises three components, a cylinder, a piston disposed in the cylinder, and a valve assembly. The piston is movable within the cylinder between an extended position and an inserted position. The valve assembly includes a plurality of valves, described in greater detail herein, that enable air to be admitted into the ball during each direction of movement of the piston. That is, air is introduced into the ball during movement of the piston from an extended position to an inserted position. And, air is introduced into the ball during movement of the piston from the inserted position to the extended position. Furthermore, it is not necessary that the piston be displaced along the entire stroke length, i.e. between a fully extended position and a fully inserted position or vice versa. The unique pump of the present invention delivers air to the ball during movement in either direction of the piston. It will be appreciated however that some minimum or threshold degree of piston travel in either direction may be necessary to achieve a sufficient pressure to cause air to enter the ball.

Referring to Figure 1 of the drawings, a sport ball **10** is illustrated incorporating a preferred embodiment inflation pump **5** of the invention. The ball which is illustrated is one typical basketball construction comprising a carcass having a rubber bladder **12** for air retention, a layer **14** composed of layers of nylon or polyester yarn windings wrapped around the bladder **12** and an outer rubber layer **16**. As will be understood, “carcass” refers to the flexible body of

the ball. For a laminated ball, an additional outer layer **18** of leather or a synthetic material may be used which preferably comprises panels that are applied by adhesive and set by cold molding to the rubber layer **16**. The windings **14** are randomly oriented and two or three layers thick, and they form a layer that cannot be extended to any significant degree. The layer formed by the windings **14** also restricts the ball **10** from expanding to any significant extent beyond its regulation size when inflated beyond its normal playing pressure. This layer **14** for footballs, volleyballs and soccer balls is referred to as a lining layer and is usually composed of cotton or polyester cloth that is impregnated with a flexible binder resin such as vinyl or latex rubber. The outer layer **18** may be stitched for some sport balls, such as a soccer ball or a volleyball. The outer layer may optionally have a foam layer backing or a separate foam layer.

Figure 2 illustrates a football **110** incorporating an inflation pump **5** according to the present invention. The football **110** comprises a carcass having a rubber bladder **112** for air retention, and an outer layer **118** of leather or synthetic material. As will be appreciated, the carcass of the football **110** may include one or more additional layers such as a winding layer or reinforcement layer, a foam or backing layer, and a secondary rubber lining layer.

Other sport ball constructions, such as sport balls produced by a molding process, such as blow molding, may also be used in the invention. For an example of a process for molding sport balls, see, for example, U.S. Patent No. 6,261,400, incorporated herein by reference.

Materials suitable for use as the bladder include, but are not limited to, butyl, latex, urethane, and other rubber materials generally known in the art. Examples of materials suitable for the winding layer include, but are not limited to, nylon, polyester and the like. Examples of materials suitable for use as the outer layer, or cover, include, but are not limited to, polyurethanes, including thermoplastic polyurethanes; polyvinylchloride (PVC); leather; synthetic leather; and composite leather. Materials suitable for use as the optional foam layer include, but are not limited to, neoprene, SBR, TPE, EVA, or any foam capable of high or low energy absorption. Examples of commercially available high or low energy absorbing foams include the CONFOR™ open-celled polyurethane foams available from Aearo EAR Specialty composites, Inc., and NEOPRENE™ (polychloroprene) foams available from Dupont Dow Elastomers.

Referring to Figure 3, incorporated into the carcass of the ball **10** of the invention during its formation is a rubber pump boot or housing **20** that defines a central opening and an outwardly extending flange **22** which is preferably bonded to the bladder **12** using a rubber adhesive. The boot **20** is preferably located between the rubber bladder **12** and the layer of windings **14**. The boot **20** may be constructed of any suitable material, such as butyl rubber, natural rubber, urethane rubber, or any suitable elastomer or rubber material known in the art, or combinations thereof. A molding plug (not shown) is inserted into the boot opening during the molding and winding process to maintain the proper shape of the central opening and to allow the bladder **12** to be inflated during the manufacturing process. The molding plug is preferably aluminum, composite or rubber, and most preferably aluminum. The central opening defined through the boot **20** is configured with a groove **24** to retain a flange extending from the upper end of a pump cylinder described and illustrated later herein. The pump cylinder can optionally be bonded to the boot **20** using any suitable flexible adhesive (epoxy, urethane, cyanoacrylate, or any other flexible adhesive known in the art).

Referring to Figures 4 and 5, the preferred embodiment dual action pump according to the present invention comprises a plunger **210** and a pump cylinder **240**. The pump cylinder **240** shown is a right cylinder, but other cylinders that are not right cylinders, such as a cylinder having a non-circular cross-section, may be used. Specifically, referring to Figure 4, the plunger **210** includes a plunger body **220** having a cap **212** defined or formed on one end, and a tubular wall **230** extending from the body **220** away from the cap **212**. The cap **212** defines an outer face **214** and a longitudinal recessed groove **216**. Disposed at a distal end of the tubular wall **230** is a sealing end **232** which defines an annular recess **234** along its outer surface. The tubular wall **230** generally extends between the cap **212** and the sealing end **232**. The tubular wall **230** has a hollow interior defined by a circumferential interior surface **236** and an interior end wall **238**. The interior end wall **238** faces the sealing end **232**. The hollow interior is accessible from the sealing end **232**. Defined proximate the sealing end **232** of the tubular wall **230** is a plunger inlet **228**. The plunger inlet **228** is preferably in the form of an aperture extending through the tubular wall **230**.

The pump cylinder **240** is generally in the shape of a right cylinder having two open ends and a unique sidewall configuration, with an interiorly disposed air transfer tube. Specifically, the cylinder **240** includes a head end **242**, a nozzle end **270**, and a generally cylindrical sidewall **246** extending therebetween. The head end **242** defines two apertures **250** and **262** which provide access to hollow passages defined within the sidewall **246**. The cylinder **240** also includes a base **272** proximate the nozzle end **270**. The inside of the cylinder **240** is generally hollow and is defined by an interior circumferential surface **290** which is the inner surface of the sidewall **246**. The sidewall **246** also defines an exterior surface, opposite from the interior surface **290**. The hollow interior of the cylinder **240** is also defined by an end wall **292** proximate the base **272**.

Disposed within the hollow interior of the cylinder **240** is an air transfer tube **280**. The air transfer tube provides communication between the interior of the cylinder **240** and the nozzle end **270** of the cylinder **240**. Preferably, the tube **280** is concentrically positioned within the center of the interior of the cylinder **240**. The air transfer tube **280** is also hollow and is supported by and affixed to the base **272** of the cylinder **240** generally along the end wall **292** of the cylinder **240**. The air transfer tube **280** preferably extends parallel and co-linearly with the longitudinal axis of the cylinder **240**. The air transfer tube **280** defines a first aperture **282** preferably near the head end **242**, and a second aperture **284**, preferably near the endwall **292** of the cylinder base **272**. The first and second apertures **282** and **284**, respectively, are preferably in the form of apertures extending through the sidewall of the air transfer tube **280**. Also disposed within the air transfer tube **280** and between the first and second apertures **282, 284**, respectively, is a one-way valve **286**. The one-way valve **286** only permits flow of air from the first aperture **282** to the second aperture **284**.

The base **272** of the cylinder **240** defines a discharge passage **274**. The passage **274** generally extends from the air transfer tube **280** to the nozzle end **270** of the cylinder **240**. And so, the discharge passage **274** provides communication between the interior of the cylinder **240** and the interior of the sport ball.

As noted, the sidewall **246** of the cylinder **240** features a unique passageway configuration. An intake, i.e., “Chamber A” intake **248**, is provided

by a first sidewall passage **252** extending between the first head aperture **250** and a first sidewall aperture **254**. The first sidewall aperture **254** is defined near the base **272** of the cylinder **240**. A one-way valve **255** is fitted over the aperture **254** that only allows air to flow into the interior of the pump cylinder **240**. It will be appreciated that although valve **255** is depicted schematically in Figure 5, preferably that valve is a one-way valve as described herein.

A further intake, i.e., "Chamber B" intake **260**, is provided by a second sidewall passage **264** extending between the second head aperture **262** and a second sidewall aperture **266**. A one-way valve **267** is disposed over the aperture **266** to only allow air to flow into the interior of the pump cylinder **240**. As with valve **255**, it will be appreciated that although valve **267** is depicted schematically in Figure 5, preferably, that valve is a one-way valve as described herein. The function and significance of the Chambers A and B, and their associated intakes, apertures, and passageways are further described below.

Upon assembly of the preferred embodiment dual action pump according to the present invention, the plunger **210** is inserted in the hollow interior of the cylinder **240**. Specifically, the plunger **210** is disposed within the annular hollow region defined between the air transfer tube **280** and the interior circumferential surface **290** of the sidewall **246** of the cylinder **240**. The plunger **210** is inserted in the cylinder **240** such that the sealing end **232** of the plunger **210** is urged toward the end wall **292** of the cylinder **240**.

As shown in Figures 6-9, the dual action pump **5** of the present invention comprises two seals referred to herein as a primary seal **300** and a secondary seal **320**. The primary and secondary seals, **300** and **320** respectively, function in conjunction with the one-way valve **286** disposed in the air transfer tube **280**, to form two pumping chambers designated herein as Chamber A and Chamber B. Chamber A is generally defined as the interior region below the primary seal **300** and Chamber B is generally defined as the interior region above the primary seal **300**. Before further describing Chambers A and B, it is instructive to further describe the primary and secondary seals **300** and **320**.

The primary seal **300** is preferably provided by an O-ring **302** disposed within the annular recess **234** defined along the sealing end **232** of the plunger **210**. The O-ring **302** is disposed within the annular region between the sealing end **232** of the plunger **210** and the interior circumferential surface **290** of the

pump cylinder **240**. As will be appreciated, as the plunger **210** is moved relative to the pump cylinder **240**, as described in greater detail herein, the primary seal **300** and specifically, the O-ring **302**, provides an air-tight seal between Chamber A below the seal **300** and Chamber B above the seal **300**. As the plunger **210** is moved along the length of the pump cylinder **240**, the O-ring **302** is carried along with the sealing end **232** of the plunger while maintaining sealing contact with the interior circumferential surface **290** of the pump cylinder **240**. A sealing member **301** is also preferably provided between the sealing end **232** and the outer surface of the air transfer tube **280**.

Although the embodiments described herein refer to an O-ring such as O-ring **302** for certain seals, it will be appreciated that other types of seals may be utilized. For example, a seal having a non-circular cross-section may be used. Of these, representative examples include, but are not limited to, loaded lip seals and U-cup type seals.

The secondary seal **320** is preferably provided by an assembly of sealing members that extend within the annular region between the air transfer tube **280** and the interior circumferential surface **290** of the pump cylinder **240**. The assembly of sealing members include an upper sealing member **322** and a lower sealing member **324**. The lower sealing member **324** is preferably disposed between the upper member **322** and the end wall **292** of the pump cylinder **240**. The secondary seal **320** operates by temporarily providing an air-tight seal between the region below it, i.e. the region defined between the lower sealing member **324** and the end wall **292**, and the region above the secondary seal **320**. The secondary seal **320** is configured to only provide this seal as the plunger **210** is withdrawn or pulled out from the pump cylinder **240**. Upon movement of the plunger **210** in an opposite direction, i.e. when inserted or pushed into the pump cylinder **240** toward the end wall **292**, the secondary seal **320** allows passage of air between the regions above and below the seal **320**.

The preferred dual action pump **5** according to the present invention also includes additional sealing members such as an inner annular seal **330** and an outer annular seal **332**. Preferably, each of the seals **330** and **332** are in the form of O-rings. The inner annular seal **330** is disposed at the distal end of the air transfer tube **280**. The inner annular seal **330** is generally seated around the perimeter of the tube **280** and extends between the outer surface of the tube **280**

and the circumferential interior surface **236** of the plunger **210**. The inner annular seal **330** prevents passage of air between the regions above and below the seal **330**. As the plunger **210** is moved relative to the cylinder **240**, the inner annular seal **330** generally maintains its position at the distal end of the air transfer tube **280**.

The outer annular seal **332** is generally seated around the perimeter of the plunger **210** and the interior circumferential surface **290** of the pump cylinder **240**. The outer annular seal **332** prevents passage of air between the regions above and below the seal **332**. As the plunger **210** is moved relative to the cylinder **240**, the outer annular seal **332** generally maintains its position proximate the head end **242** of the cylinder **240**.

The inner and outer annular seals **330** and **332**, in addition to performing the noted sealing functions, also serve to maintain alignment of the plunger **210** with respect to the pump cylinder **240**. That is, the seals **330** and **332** promote alignment between the plunger **210** and the cylinder **240**, and preferably, ensure that the longitudinal axis of the plunger **210** is not only parallel with the longitudinal axis of the cylinder **240**, but also that these two axes are co-linear with each other. Furthermore, the seals **330** and **332** not only promote the noted alignment between the plunger **210** and the cylinder **240**, but also ensure that this alignment is maintained during movement of the plunger **210** relative to the cylinder **240**.

In a preferred embodiment of the pump, a spring (not shown) is provided within the pump to urge the plunger **210** up and away from the nozzle end **270** of the cylinder **240**. The plunger may optionally contain a pressure-indicating device (not shown), such as a ball or slide, and pressure indication lines, and/or a pressure relief mechanism to reduce the pressure of the ball.

Generally, the operation of the preferred dual action pump **5** is as follows. When the plunger **210** is pulled up or out (reverse stroke) from the cylinder **240**, the secondary seal **320** is closed, and the valve **255** for Chamber A is open, allowing air to fill Chamber A. When the plunger **210** is pushed in or down (forward stroke) with respect to the cylinder **240**, the secondary seal **320** opens, the valve **255** closes, and the one-way valve **286** opens to allow air from Chamber B to enter the ball through the aperture **284** and then through the nozzle end **270**. While the air in Chamber B is being forced into the ball, the

Chamber A is drawing in air from outside the pump. As the piston is pushed back in, the air in the Chamber A enters the ball by the action of the piston while Chamber B fills with air again. This process is repeated until the desired amount of air has been added to the ball. With each stroke, both in and out, air is forced into the ball.

Unlike a typical single action pump where the seal between plunger and cylinder only forms a seal in one direction, the primary seal **300** of the preferred dual action pump **5** seals the Chambers A and B in both stroke directions. This allows the air in Chamber A to be forced into the ball during the down or forward stroke while preventing the air from escaping. The seal provided by seal **300** also allows the air that is drawn into Chamber B to be forced into the air transfer tube **280** and then into the ball during the up or reverse stroke while the Chamber A refills with air through the Chamber A intake **248**.

More specifically, the operation of the preferred dual action pump **5** is explained as follows with reference to Figures 6-9. Figures 6 and 7 primarily illustrate the action of the pump with regard to Chamber A below the primary seal **300** during a forward and reverse stroke, respectively. Figures 8 and 9 primarily illustrate the action of the pump with regard to Chamber B above the primary seal **300** during a forward and reverse stroke, respectively.

As shown in Figure 6, as the plunger **210** undergoes a forward stroke, air residing in Chamber A, denoted by the stippled region in Figure 6, is compressed and urged to flow through the nozzle end **270** into the ball. This occurs since upon compression of the air within Chamber A, the one-way valve **255** closes thereby preventing escape of air from Chamber A into the Chamber A intake **248**. Concurrently with the compression occurring within Chamber A, the secondary seal **320** opens to allow passage of air from the upper portion of Chamber A, i.e. between the sealing end **232** of the plunger **210** and the upper sealing member **322**, to the lower portion of Chamber A, i.e. between the lower sealing member **324** and the end wall **292**. Concurrently with the compression occurring within Chamber A, the one-way valve **286** disposed within the air transfer tube **280** closes to prevent passage of air within the tube **280**. As the plunger **210** undergoes its forward stroke, the increase in pressure within Chamber A causes air flow from that chamber past the secondary seal **322**,

through the aperture **284** defined in the air transfer tube **280**, and through the nozzle end **270** and into the ball undergoing inflation.

Figure 7 illustrates plunger **210** undergoing a reverse stroke. Upon movement of the sealing end **232** of the plunger **210** away from the secondary seal **320**, the volume of Chamber A is increased, thereby reducing the pressure therein. The stippled region in Figure 7 represents Chamber A. Such pressure change opens the one-way valve **255** of the Chamber A intake **248**. This action draws air through the Chamber A intake defined by the first head aperture **250**, the first sidewall aperture **254**, and the first sidewall passage **252** extending therebetween (see Figure 5). Concurrently with the reverse stroke of the plunger **210**, the secondary seal **320** closes which prevents air withdrawal from the lower portion of Chamber A or from the ball via the nozzle end **270**.

Figure 8 shows the plunger **210** undergoing a forward stroke. During movement of the sealing end **232** and primary seal **300** of the plunger **210** towards the secondary seal **320**, the volume of Chamber B, i.e. the interior region above the primary seal **300**, increases. The stippled region in Figure 8 denotes Chamber B. Such volume increase results in a pressure decrease within that chamber and opens the one-way valve **267** disposed at the second sidewall aperture **266** of the Chamber B intake **260** (see Figure 5). Opening of the valve **267** draws air through the Chamber B intake into the Chamber B defined generally between the outer annular seal **332** and the primary seal **300**. Upon the plunger **210** undergoing a forward stroke, the operation of the secondary seal **320** and the one-way valve **286** of the air transfer tube **280** are as previously described with regard to Figure 6.

Figure 9 illustrates the change in Chamber B during a reverse stroke of the plunger **210**. The stippled region in Figure 9 illustrates Chamber B. Upon withdrawal of the plunger **210**, the contents of Chamber B increase in pressure thereby closing the one-way valve **267**. The increase in pressure within Chamber B causes air flow from Chamber B through the first aperture **282** defined at the distal end of the air transfer tube **280**, downward through the tube **280**, through the now open one-way valve **286**, and into the ball through the nozzle end **270**. Upon the plunger **210** undergoing a reverse stroke, the operation of the secondary seal **320** is as previously described with regard to Figure 7.

As best shown in Figures 4 and 11, preferably, disposed near the distal end of the plunger **210** are two outwardly extending flanges **224** and **226** that cooperate with a cylinder cap **350** to hold the plunger **210** within sidewalls **246** of the cylinder **240**, and to release the plunger **210** for pumping. The cylinder cap **350** is depicted in Figures 10 and 11. The cylinder cap **350** is secured to the distal end of the cylinder **240**. The plunger **210** extends through the center of the cylinder cap **350**. The cap **350** is preferably cemented into the cylinder **240** using a suitable adhesive, such as a UV cured adhesive. Figure 10 shows an isometric view of the bottom of the cylinder cap **350** and illustrates open areas **352** on opposite sides of the central opening through which the two flanges **224** and **226** of the plunger **210** can pass in the unlocked position. In the locked position, the plunger **210** is pushed down and rotated such that the two flanges **224** and **226** pass under projections **354** and are rotated into locking recesses **356**.

As shown in Figures 4 and 11, attached to the upper end of the plunger **210** is the cap **212** that is designed to essentially completely fill the hole or aperture in the carcass. In some embodiments, such as a basketball or football, the button or cap **212** is preferably flush or essentially flush with the surface of the ball. In other embodiments, such as a soccer ball, the button or cap **212** is preferably positioned below the surface of the ball. This button **212** may be of any desired material. Examples of materials suitable for use as the button or cap **212** include urethane rubber, butyl rubber, natural rubber or any other material known in the art. A preferred rubber for use as the button or cap is a thermoplastic vulcanizate such as SANTOPRENE™ rubber, available from Advanced Elastomer Systems, Akron, OH. The button or cap should match the texture or feel of the outer surface of the ball. The surface of the button or cap may be textured to increase gripping characteristics if desired, such as for a basketball. For a soccer ball, the surface may be smooth.

In a preferred embodiment, fibers or other reinforcing materials for the cap may be incorporated into the rubber compound or thermoplastic material during mixing. Examples of fibers materials suitable for use include, but are not limited to, polyester, polyamide, polypropylene, Kevlar, cellulistic, glass and combinations thereof. Incorporation of fibers or other reinforcing materials into the button or cap improves the durability of the button and improves the union of

the button or cap and the piston rod, thus preventing the button or cap from shearing off during use. Although the pump would still function without the button, it becomes very difficult to use.

Preferably, the button or cap **212** is co-injected with the plunger **210** as one part. Alternatively, the button or cap **212** may be co-injected with a connecting piece, and the button or cap **212** and connecting piece may then be attached to the upper end of the plunger **210** using an adhesive suitable for bonding the two pieces together. Co-injecting the button **212** and the plunger **210** as one part, or alternatively, the button **212** and the connecting piece as one part that is mounted to the plunger **210**, provides a more durable part that is less likely to break or come apart during routine use of the ball. The button or cap material and the plunger material need to be selected such that the two materials will adhere when co-injected. Testing of various combinations has shown that co-injecting or extruding a soft rubber button, such as a button comprising SANTOPRENE™, and a harder plunger, such as polycarbonate or polypropylene and the like, provides a durable bond without the need for adhesives.

The plunger **210** and the connecting piece may be formed of any suitable material, such as, but not limited to, polycarbonate (PC), polystyrene (PS), acrylic (PMMA), acrylonitrile-styrene acrylate (ASA), polyethylene terephthalate (PET), acrylonitrile-butadiene styrene (ABS) copolymer, ABS;/PC blends, polypropylene (preferably high impact polypropylene), polyphenylene oxide, nylon, combinations thereof, or any suitable material known in the art. Materials with high impact strength are preferred. The material used for the plunger is preferably clear or transparent, especially if a pressure-indicating device is used so that the user can view it.

Referring further to Figure 11, mounted on the upper surface of the cylinder cap **350** is a pad **360** that is engaged by the button **212** when the plunger **210** is pushed down to lock or unlock the plunger **210**. The pad **360** provides cushioning to the pump. The outer face **214** of the button or cap **212** may be textured or smooth to match the feel of the ball, as desired. For basketballs, it is preferable that the top of the button or cap is textured, while for other sport balls, such as soccer balls and footballs, the top of the button is preferably smooth.

Figures 6-9 of the drawings show the nozzle end **270** of the pump **5**. Figure 12 is a detailed cross section of that component. Shown in Figure 12 is one preferred embodiment of a one-way valve assembly of the duckbill-type that is disposed in the nozzle **270**. This assembly comprises an inlet end piece **269**, an outlet end piece **271** and an elastomeric duckbill valve **370** captured between the two end pieces. The end pieces **269** and **271** are preferably plastic, such as a polycarbonate, polypropylene, nylon, polyethylene, or combinations thereof, but may be any material suitable for use. The end pieces may be ultrasonically welded together. Although any desired one-way valve can be used on the exit nozzle **270** and although duckbill valves are a common type of one-way valves, a specific duckbill configuration is shown in Figure 13. The duckbill valve **370** is preferably formed of an elastomeric silicone material and is molded with a cylindrical barrel **372** having a flange **374**. Inside of the barrel **372** is the duckbill **376** which has an upper inlet end **378** molded around the inside circumference into the barrel **372**. The walls or sides **380** of the duckbill **376** taper down to form the straight-line lower end with the duckbill slit **382**. The duckbill functions wherein inlet air pressure forces the duckbill slit **382** open to admit air while the air pressure inside of the ball squeezes the duckbill slit closed to prevent the leakage of air. Such a duckbill structure is commercially available from Vernay Laboratories, Inc. of Yellow Springs, Ohio. Any type of one-way valve or other valve capable of sealing known in the art may be used, as long as it prevents air from flowing out of the interior of the ball when not desired.

A pump assembly of the type described and illustrated herein is preferably made primarily from plastics such as polystyrene, polyethylene, nylon, polycarbonate and combinations thereof, but it can be made of any appropriate material known in the art. Although the assembly is small and light weight, perhaps only about 5 to about 25 grams, a weight may optionally be added to the ball structure to counterbalance the weight of the pump mechanism. In such an application, the weight, i.e. the counterweight, is positioned on or within the ball, and has a suitable mass, such that the resulting center of mass of the ball coincides with the geometric center of the ball. In lighter weight or smaller balls, such as a soccer ball, the pump assembly may weigh less and/or be smaller (shorter) than a corresponding pump assembly for a heavier ball, such as a basketball. Figure 14 illustrates such a counterbalance arrangement wherein a

pump mechanism generally designated as **405** is on one side of the ball and a standard needle valve **410** is on the opposite side of a ball **400**. In this case, the material **412** forming the needle valve **410** is weighted. Additional material can be added to the needle valve housing or the region surrounding the valve. Alternatively, a dense metal powder such as tungsten could be added to the rubber compound. The use of another pump or inflation valve is referred to herein as a secondary pump or inflation valve.

The description thus far and the referenced drawings disclose a particular and preferred pump configuration. However, other pump arrangements can be used within the scope of the invention, as long as they utilize at least two chambers to provide for dual action. Examples of other pump arrangements that may be used with the invention are shown in co-pending Application Serial Nos. 09/594,980, filed June 15, 2000; 09/594,547, filed June 14, 2000; 09/594,180, filed June 14, 2000; and 09/560,768, filed April 28, 2000, incorporated herein by reference. Additional details and features that may be implemented in conjunction with the balls and pumps described herein are provided in U.S. Application publication No. US 2002/0187866, filed as Serial No. 10/183,337 on June 25, 2002; U.S. Patent No. 6,491,595, filed as Serial No. 09/712,116 on November 14, 2000; and U.S. Patent No. 6,287,225 filed as Serial No. 09/478,225 on January 6, 2000, all of which are hereby incorporated by reference.

Since the pressure in a sport ball can be too high through overinflation or a temperature increase, or too low through underinflation or air loss, it is an advantage to have a pressure-indicating device that is integral to the pump. If the pressure is too low, additional air may be added using the self-contained pump of the invention. If the pressure is too high, the pressure may be relieved by bleeding pressure from the ball with the conventional inflating needle or other implement that will open the conventional inflation valve to release air. Alternatively, the pump may have a mechanism that allows the pressure to be relieved, either through action of the pump, or through the use of a relief mechanism built into the pump, such as a mechanism to open the one-way valve if desired to allow air to flow out of the interior of the ball. The pressure-indicating device of the present invention may then be used to determine if the

ball is correctly inflated. If too much air is removed, additional air may be added using the pump.

The foregoing description is, at present, considered to be the preferred embodiments of the present invention. However, it is contemplated that various changes and modifications apparent to those skilled in the art may be made without departing from the present invention. Therefore, the foregoing description is intended to cover all such changes and modifications encompassed within the spirit and scope of the present invention, including all equivalent aspects.